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The origin of the gulf of St. Lawrence

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Present day geography contemplates not only the surface of the earth and its forms of land and water, but considers also the physical and human causes that are modifying it. The geographer sees these things and looks forward ; the geologist sees present conditions and looks backward for their inception—and then again forward in the perspective of cause and effect. It is hard to draw the line between these two fields of scientific interest. Some have tried to circumscribe each but it is a bootless effort. Each trenches on the other. At all events every geographer is something of a geologist. And this may be my justification in endeavoring here to find a clue to the origin of a geographic feature of so deep interest to us all as the Gulf of St. Lawrence. We are very apt to take such a geographic fact for granted as it is and to let our geography end with a knowledge of its outlines, the contours of its shores and its bottoms. To unravel its history and to find the causes which have brought it into being is a task that will be fruitless on the face of the facts as they present themselves to the maker of charts. The key lies in the geological birth and growth of the whole land mass by which such a body of water is embraced.

So to find the real factors in the making of this classical and romantic body of water, we shall have to go well back to the early events in the making of the land.

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Fundamental among these facts is the existence of the great mass of crystalline rocks that sweeps from Labrador to the Laurentides and northwestward to Alaska—the *Canadian Shield*—as a continental land mass rising above the waters of the primitive ocean. Its shores were washed by the first sea whose life records have been kept for us in the sediments which, now changed to shale, sandstone and limestone, bound all its ancient shores. On the south coast of this Canadian continent, in the ages of its independent existence, lay, in the longitude of Montreal, a great tongue or peninsula which form the Adirondack mountains of New York; and still further south, perhaps, were long and narrow land masses that kept their uncertain heads above water for no great time. About these continental and insular shores and on the bottom of these shallow intervening seas were laid down, to hundreds and even thousands of feet, the sediments of the ocean filled with the remains of living beings that played out their days in succession as unknown time rolled by. Thus the shallow sea became overloaded with its burden of deposits—a load of soft and plastic material made still more yielding by being carried constantly further downward into regions of higher heat as the later deposits continued to pile on top of the earlier. Against this soft and weakened mass of deposits stood, on one side, the great weight of the waters in the vast Atlantic ocean basin, pressing upon them landward and on the other, the irresistable crystalline continent—the Canadian shield.

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The outcome was inevitable; the whole mass of sea deposits was slowly turned up into great mountain folds and throughs—not all at once but slowly, fold after fold, to unmeasured hights, and often the folds at the south were thrust upon and over folds at the north. Thus, broadly and rapidly speaking, the Appalachian system of mountains was built up through the ages, not at any one time in geological

history, but beginning slowly and early at the north and ending late at the south. In the early development of this structure the shove of the soft rocks against the crystalline shield was so valiantly withstood at the north, that there, along the southern outline of that shield, from Lake Ontario to Natashkwan, the softer rocks broke down, making, where the two lay in contact, a deep and broad fracture extending from southwest to northeast. The existence of this break or fault in the rocks was long ago signalized by Sir William Logan* and it is known today as "Logan's Fault". It is beyond doubt the determinant factor in the existence and course of the St. Lawrence river. "Logan's Fault" gave birth to the river by setting down a line of weakness along whose crushed and broken rock masses the continental waters draining to the sea could find their least obstructed passage ; and thus began the oldest of all great rivers of the earth and the oldest of all rivers on the earth of which we have any definite record.

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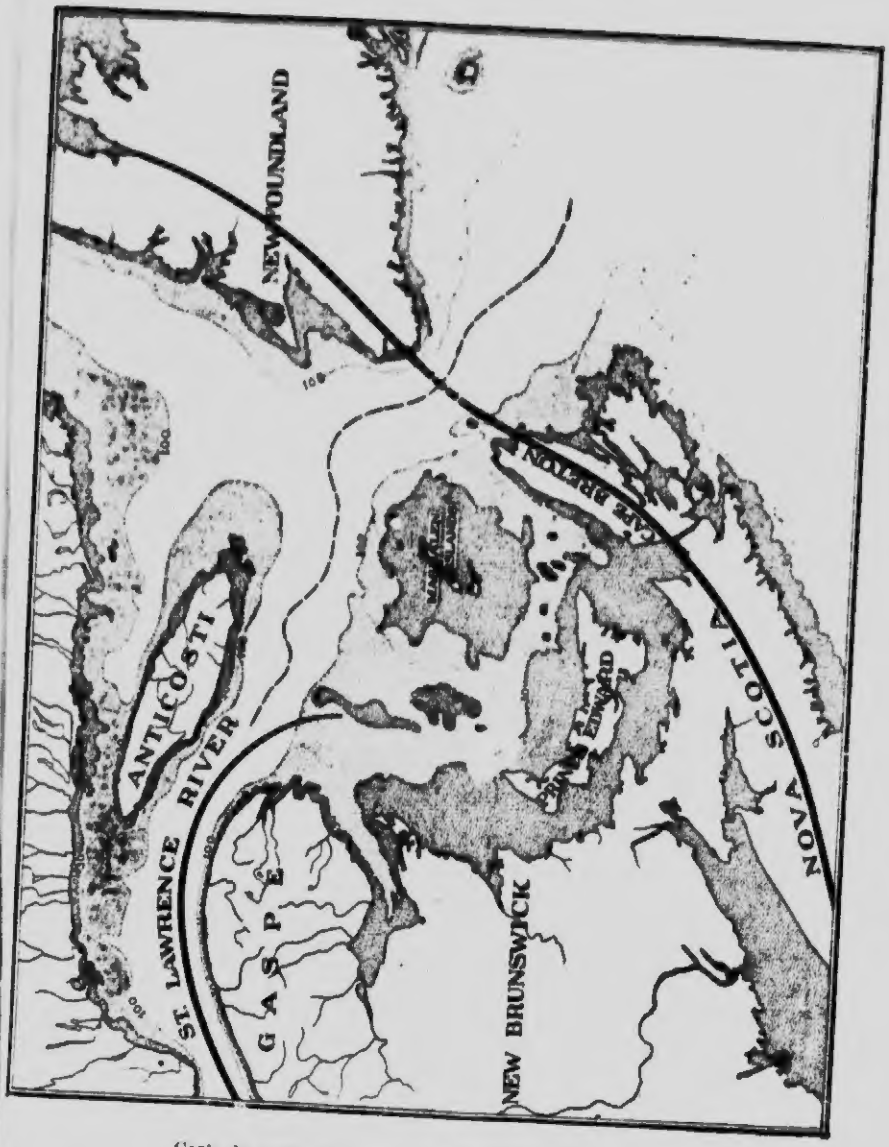
* One who has followed closely in the footsteps of Sir William Logan in his geological work in eastern Quebec may perhaps be permitted, without impropriety, to revert to the extraordinary achievements of this great Canadian, and his distinguished services to geological science.

The year after Sir William organized the Geological Survey of Canada, he began his official career by explorations in the Gaspé peninsula. Laboring in the early 40's among the picturesque sea cliffs of that inviting country, traversing its wildernesses, he determined its geological systems with their wealth of unrecorded facts and made of the Gaspé country ground that will always be of classic worth to geological science. Had he done no more, he would have served well ; but he did do vastly more in the development of the mineral resources of the Dominion. A country that is rich and strong and great will not forget its obligation to such a distinguished servant. France commemorates by public memorials the services of its eminent civilians more often than it does those of its military and naval heroes. Such a memorial to Logan is wanting. There stands a rock cliff in the heart of the village of Percé, overlooked on one side by towering sea cliffs and on the other by consecrated mountains over which Logan labored in his early work, and here might well be placed a tablet commemorative of the lasting achievements of his great career.

The Appalachians of the Eastern Townships follow the normal northeast-southwest course, but in Gaspé, as every one knows, they swing about into a curve like a swan's neck or the upper line of the letter *S*. There the northern mountains end at Cape Gaspé on the land but their vanishing point can be followed some 15 miles off to sea southeast, to the rocky shoal known on the charts as the "American Bank". This mountain ridge or orogenic axis at the north is unlike that of the Appalachian ranges at the south. The ridges of these ancient mountains cross Nova Scotia in the normal trend; their southwesterly extension off New England is largely buried beneath the sea, and to the northeast they continue on their course across Newfoundland. Looking at the sketch map adjoining, one sees the different curves of these mountain axes at north and south and between them an area which we must believe was less involved in the profounder or axial movement of these disturbances —the region of central and northern New Brunswick. We are speaking of times and conditions when there was no Gulf of St. Lawrence, when the elevation of the mountains had brought, if not quite all, at least most of the land now at the bottom of the Gulf, above the water line and the continent extended without break from the present eastern shores out to the islands and across to Newfoundland. For long this ancient coast line was a series of mountain folds between which the ocean waters entered in broad channels southwestward, laying down the deposits of their own time in their due succession. But from the time the most ancient of these mounatain folds were made, when the riges at the north took on their singular curvature, the whole area between their end and the mountain axes to the south became an area of weakness and instability. This sigmoid curve at the north in a factor of profound meaning in the making of the Gulf. It seems to be due to the recoil, as one might say, of the softer rocks in their pressure against the irresistable Canadian Shield, so that the line of fracture or fault was deflected at its outer end southward in such a



Carte du golfe St-Laurent et des terres avoisin tes.

(The areas of the bottom down to 30 and 100 fathoms are indicated by close and coarse stippling. The broken curved line through the gulf is the line of grea est depth. The heavy black lines are the orogenic or mountain axes at north and south.)

way, as to break through the mass of sedimentary deposits. Thus the St. Lawrence river has almost of necessity, an outer curve that follows the course of the fault and of the folded slate and limestone mountains of Gaspé, while to the north of the fault line and the buried river channel lies the island of Anticosti whose rock strata, full of fossils, lie almost horizontal and were beyond the influence of the mountain making.

This revulsion from the north projected the axial line of resistance southward against the normal course of the other folds and protruded into them a disturbing antagonistic force. The Nova Scotia anticlines were beyond the reach of this projected influence but the folds between were disordered and crosscut and weakened. The picturesquely ragged coast at Percé is due to a complete collapse of a tremendous mountain fold which has vastly deranged the original succession of the rock strata.

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The Gulf lands had sunk low soon after the mountain making period was over, and during the succeeding times of the Coal and probably even before, it was chiefly a vast drainage basin receiving fresh land waters with their heavy loads of sediment, then again elevated into a sand desert or great stretches of bars and dunes, and still at times depressed again so that the salt waters came in bringing their characteristic life forms. Then again, in later geological days, after the day of the Coal and the sand bars was over, the region was again elevated into land and the rocks of that land still fringe the Gulf shores and make the islands of Prince Edward and the Magdalens.

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The subterranean course of the St. Lawrence river across the Gulf is still clearly indicated on the Admiralty charts ; from its present mouth southeast it extends, far to

the east of Gaspé, east of the Magdalen Islands and thence outward to the Atlantic by the passage between Cape Breton Island on the west and Newfounland on the east (Cabot Strait). This valley was made when the gulf bottom was land.

The chart accompanying shows the curves of 30 fathoms and 100 fathoms. It is very clear that the deep channel outside the 100 fathom line could not be made by the scouring of the present stream over the rocky bottom of the Gulf. A more detailed chart of the Gulf would show these depths dropping off from the shore in a succession of stages, or one might say, terraces, indicative of the gradual and periodical rise of the land bounding the ancient river while the river itself was cutting downward and narrowing its channel as the Gulf lands rose. It is not to be conceived that this channel through the Gulf is as ancient as the channel between the shores of Gaspé and the Quebec Labrador. The lands which the lower channel cuts are of later birth than those at the north and in its earlier stages we may believe that the river debouched into a shallow sea much as it does today into the Gulf. The student of the chart will observe that there is a branch channel leading off in the direction of the Strait of Belleisle but it is a shallower through than that to the southeast. The line of deepest water is in the southeast channel and there is a difference in maxima of depth between the two of 155 fathoms, the greatest depth in the northwest through being 145 fathoms and in the southwest 300 fathoms.

The southeast channel drops quite steeply 1700 feet below the broad 100 fathom plateau and this is twice the depth of the northeast course.

It would seem that the northeast course was a river valley of earlier date than the southern part of the southeast channel, that the river abandoned it for sufficient cause, possibly change in submarine level or blockage by a heavy ice sheet, and then continued to erode its present buried channel to still greater depths.

The courses of existing submarine currents over this region are not yet sufficiently determined to permit us to speak definitely regarding the outpush of the waters through the southeast channel and yet it is practically certain that this is the predominent trend of the major deep water movements of the Gulf.

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The Gulf of St. Lawrence thus owes its existence chiefly to two determinant factors of very ancient date: the break down of the rocks which produced "Logan's Fault"; the curvature of the northern orogenic axis which effected a syntaxis or a protrusion of the northern against the southern Appalachian folds. The broken down basin between is a natural and resultant area of rock weakness which has had its short periods of low elevation above the sea, but longer periods of depression.

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